DEPARTMENT OF THE INTERIOR, CANADA

HON. CHARLES STEWART, Minister
W. W. CORY, C.M.G., Deputy Minister
J. D. CRAIG, Director General of Surveys
NOEL J. OGILVIE, Director Geodetic Survey of Canada

ANNUAL REPORT

OF THE DIRECTOR

OF THE

GEODETIC SURVEY OF CANADA

FOR THE

FISCAL YEAR ENDED MARCH 31, 1928

1927/28

GEODETIC SURVEY OF CANADA

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1929

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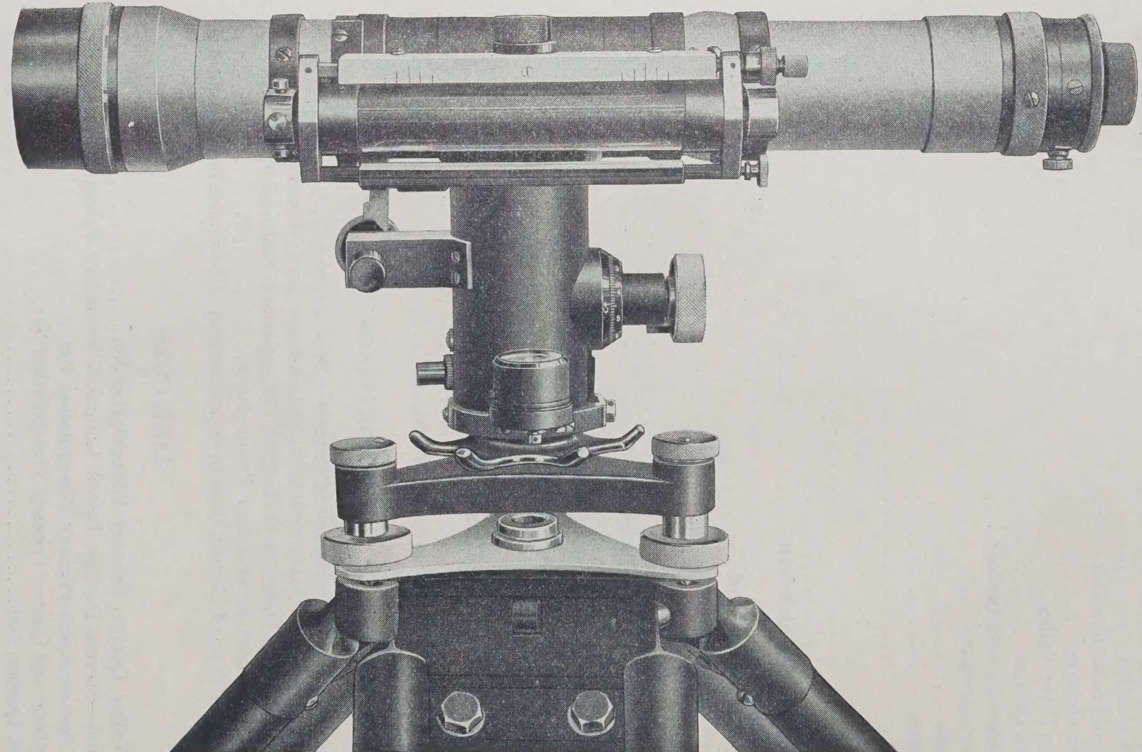


Precise Level—Zeiss Pattern

Weight of instrument, $8\frac{3}{4}$ lbs.; weight of case, 7 lbs.; weight of tripod, 10 lbs.

This pattern as well as the United States Coast and Geodetic Survey Pattern is used by the Geodetic Survey of Canada.

THE GEODETIC SURVEY OF CANADA

REPORT OF THE DIRECTOR, NOEL J. OGILVIE

INTRODUCTION

The operations of the Geodetic Survey of Canada undertaken during the year ended March 31, 1928, both in the field and in the office, were carried out successfully. Field parties operated in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Inquiries for control datums as to geographic positions and as to elevations above mean sea level were received from surveyors and engineers in increased numbers during 1927-28. On every occasion the results of the latest refinements in latitudes and longitudes and precise levels as determined by the Geodetic Survey were promptly furnished. Certain recent refinements in the determination of the elevations of a number of points in Canada have been published and others are contained in publications of the Geodetic Survey which are at present in press.

The International Geodetic and Geophysical Union has acknowledged the receipt of material prepared by the Geodetic Survey of Canada on the occasion of the Third General Conference of this body held at Prague, Czechoslovakia, September, 1927.

Due to the large area now covered, peculiar problems have arisen in the geodetic survey of Canada, and in order that the best solution may be found for each problem, certain work has been rearranged.

By this means proper expression can be given in the research undertaken for regulating the accuracies of geodetic work as it extends over Canada. The responsibility of carrying out this new work comes under the Divisions of Mathematical Research, Triangulation Adjustments and Precisions, and Precise Level Adjustments and Precisions.

From different surveys engineers and universities appreciative acknowledgements of the value of a recent publication on geodesy have been received.

Special investigation has been undertaken as to the conformation of the precise traverse to the shape of the earth. This has become urgent on account of the extensive precise traverses used by the Geodetic Survey in British Columbia.

Certain new types of instruments were studied for the purpose of perfecting the instruments of the Survey. Where the topography of the country to be surveyed permits suitable sites for triangulation stations, the lighter type of instrument is selected, providing that the maximum power of the equipment is not overtaxed thereby.

The wireless method of determining longitudes has been continued and has proven highly satisfactory, on account of the facility with which signals are received for clock comparison at observing stations regardless of distances.

Length of Lines on Primary Triangulation

Until a few years ago lines of the maximum length possible with standard equipment were judged a desirable feature of primary triangulation nets in Canada. Reconnaissance officers went to the field with this idea in mind and were correspondingly elated if the topography of the country permitted the covering of a large area with a small number of stations. Lines up to sixty miles long were quite common.

Although the use of lines of maximum length was formerly accepted, practice has gradually changed. The conclusion has now been reached that while topographical conditions must remain a governing feature, the use of lines longer than twenty-five miles is, in general, undesirable in Canada.

Topographical conditions, while they have a governing influence in all cases, may be of paramount importance in certain instances. For example, at times it may be necessary to measure across a body of water, free from islands, where the shortest lines possible far exceed the accepted maximum of twenty-five miles. Transportation facilities, atmospheric conditions and the character of the vegetal cover may also be of importance in determining the length of line which is best suited to the conditions present in each case.

Apart from these governing aspects three conditions influence the conclusions reached regarding the desirable length of lines: (1) The accuracy of the triangulation must be maintained, (2) The triangulation must be of the greatest service to users of these data, (3) The cost should be as low as possible consistent with (1) and (2).

The basis of the long-line practice is that a larger area is covered with fewer stations and hence with fewer sources of error; also fewer base lines and Laplace stations are required than where short lines are employed.

The weakness of this practice lies in the well known fact that a greater proportion of loss in accuracy in long line nets exists in the base nets where short base lines are connected to long triangulation lines, than in the main triangulation between base nets. This is due to the fact that a number of the angles employed in expanding from a short base line to the long base lines tend to be small, and the effect on the calculated distances between stations of errors in small angles is much more serious than in the main net with its, generally, larger angles. With short lines these small angles and poor geometrical conditions are not so liable to occur; sometimes it is even possible to measure a main scheme line as a base line, thereby carrying an accuracy into the main net greater than that which results with long main lines.

While it is true that a larger number of base lines and Laplace stations are required with short than with long lines, this fact is considered to be of less importance in the determination of the advisable length of line than it was a few years ago. This is due to the greater flexibility of methods, the decreasing cost of base line measurement and the ease, due to the advent of wireless, of establishing Laplace stations wherever required.

From the point of view of utility of triangulation, short lines are much to be preferred to long lines, the best results being obtained when the main stations are from ten to fifteen miles apart. With longer lines (over twenty-five miles) it is difficult to obtain by intersection from the main stations the positions of the desirable number of church spires, lighthouses, etc. which for geographic purposes are frequently as useful as, and generally more conveniently situated than, the triangulation stations themselves. As a basis for secondary triangulation, where the telescope pointings are usually made in the daytime on signals, shorter lines in the primary triangulation are obviously preferable to long lines from the standpoint of both convenience and accuracy. Special equipment (heliotropes or signal lamps) is required for pointing accurately over long lines, equipment which is not regularly carried by secondary triangulation

parties. The same decrease in accuracy is encountered in "stepping down" from long primary lines to short secondary ones as is met with in the expansion from short base lines to long triangulation sides due to poor geometrical conditions, and this results in a lower precision in the lengths of these secondary lines.

Where long lines are unavoidable it is the general custom in Canada to insert supplementary stations in the main scheme, both to define the position of church spires, chimneys, etc. and to serve as a more convenient basis for secondary triangulation.

The cost of all operations—reconnaissance, station preparation and tower building, angular measurements, measurement of base lines and establishment of Laplace stations—depends on and varies with transportation facilities, topographic conditions and length of lines. The latter is the only one the variation of which is partially within the power of geodetic engineers, and under modern operating conditions it is found that, speaking generally, and excluding the above governing conditions, the cost of triangulation is moderately constant for lines up to twenty-five miles in length, while above this limit the cost materially increases.

Taking into account questions of accuracy, utility and cost, and recognizing that each type of country presents a separate problem, the present practice in Canada is to adopt twenty-five miles as the maximum length of lines on primary triangulation.

TRIANGULATION

Field work in general suffered on account of rain and fog during the season of 1927. The stations at which angular measurements were completed totalled only seventy-five per cent of the number completed in 1926. Operations on the coast of Nova Scotia were almost completely halted during July on account of fog. Also in Quebec and Northern Ontario work planned for July was unfinished at the end of the season. In Northern Alberta and British Columbia, rain in May and June delayed operations.

The following is a tabular statement of the triangulation operations of the Geodetic Survey of Canada during the season of 1927:—

Field operation	1927 Season		Total to Date	
	Axial length miles	Area square miles	Axial length miles	Area square miles
Completed primary triangulation	388	6,320	5,404	160,300
Completed secondary triangulation	72	1,400	874	4,260
Reconnaissance completed	730	10,500	....	....
Precise traverse	....	....	380	....

Primary Triangulation in Nova Scotia and in the Matapedia Valley, Quebec

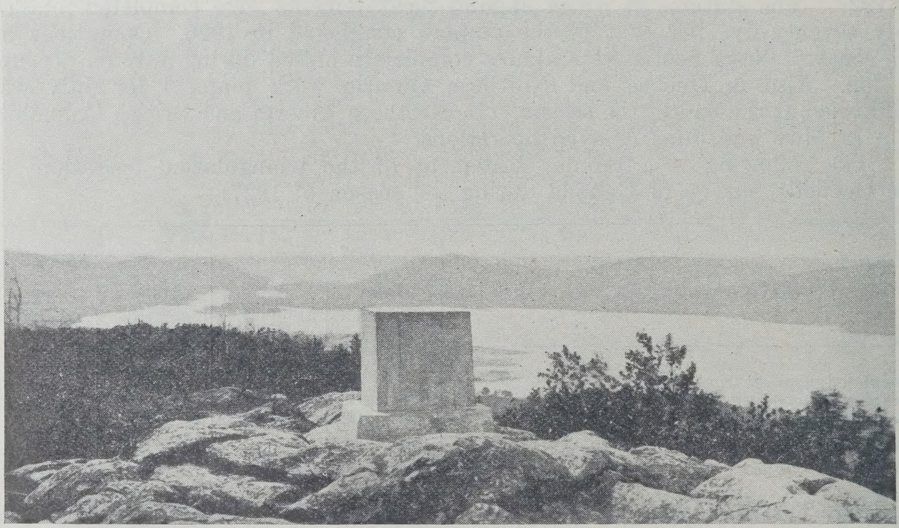
Results Obtained.—*Reconnaissance*—In Matapedia valley, Quebec: 12 stations selected; axial length of net, 89 miles. *Station preparation*—In Nova Scotia: 9 towers built, 10 standard monuments erected—In Matapedia valley: 2 towers built, 7 stations with vistas prepared, 9 standard monuments erected. *Angular measurements*—In Nova Scotia: 19 stations completed, positions of 9 lighthouses established; axial length of net, 65 miles; area, 1,100 square miles—In Matapedia valley: 5 stations completed, axial length of net, 16 miles; area 450 square miles.

Work was completed on a net running southwest from Halifax to Liverpool, thence 30 miles north as far as Caledonia. A number of hydrographic stations and lighthouses, as well as topographic control stations, were connected to this net. It therefore co-ordinates all surveys in this portion of the province.

It had been intended that this net would extend around the southern end of Nova Scotia to Yarmouth and connect with the triangulation at the mouth of the bay of Fundy. With this in view reconnaissance was completed as far as cape Sable in 1905 (see sketch on page 20 of the Annual Report of the Director of the Geodetic Survey of Canada for 1926). It was found, however, that beyond Liverpool the cost of a net would be excessive on account of the large number of high towers required; and as the control requirements for this district could be more economically met, temporarily at least. by other means it was decided to conclude the triangulation near Liverpool and Caledonia.

The southwest coast of Nova Scotia is a rockbound, fog-swept area in which angular measurements are obtained with difficulty. In order to utilize that part of the season which is relatively free from fog, a party engaged on tower-building operations commenced work the first of May and two angular-measurement parties started about the middle of the month. In addition to the delays due to fog, difficulties were encountered owing to the fact that several stations were located on islands which could only be visited in periods of calm weather. Station preparation in the vicinity of Liverpool, N.S., and northward on a spur half-way to the bay of Fundy was completed by the end of July, and angular measurements from Chester, N.S., westward over the same territory by the middle of August.

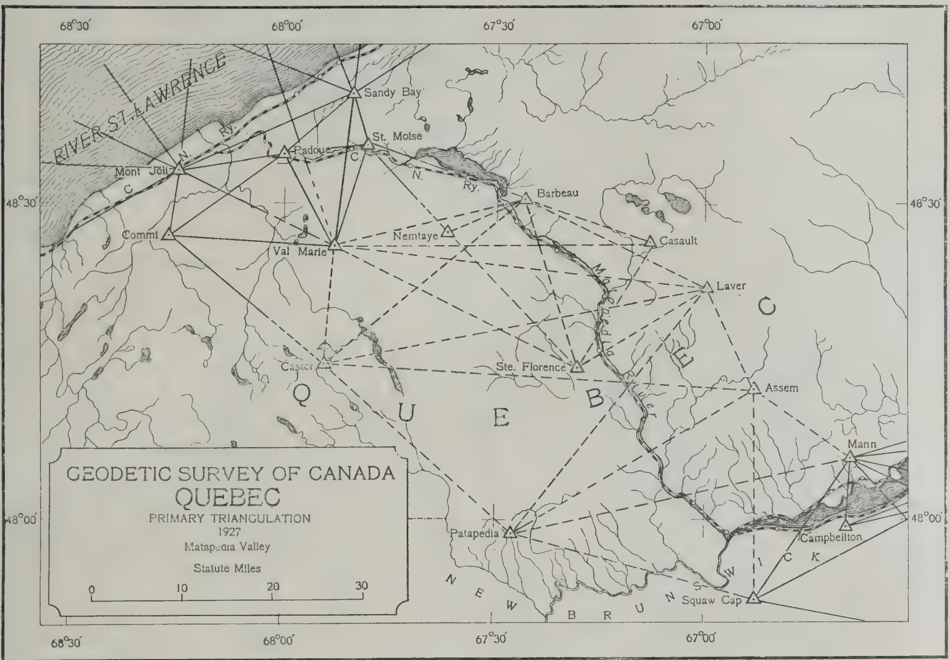
Upon completion of its work in this area, each party moved northward to the St. Lawrence river near Mont Joli, Que., from which point stations had been selected early in the season along the Matapedia valley to connect with Chaleur Bay triangulation near Campbellton, N.B., 110 miles distant by rail.



Campbellton Geodetic and Astronomical station on Sugar Loaf mountain near Campbellton, N.B. Elevation 930 feet.

All areas in the Maritime Provinces, with the exception of a few isolated sections, are now well supplied with first order triangulation control. The position of the most commanding hill in New Brunswick, Bald mountain, 2,800 feet high, has not yet been accurately determined, and on account of its commanding situation in the interior of the province an effort will be made in 1928 to extend the Matapedia Valley net southerly about 30 miles so as to take in this well known topographic feature.

A sketch of the Matapedia Valley triangulation appears below, while the progress of the Nova Scotia triangulation may be followed by referring to the sketch on page 20 of the Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ended March 31, 1926.



Triangulation in British Columbia

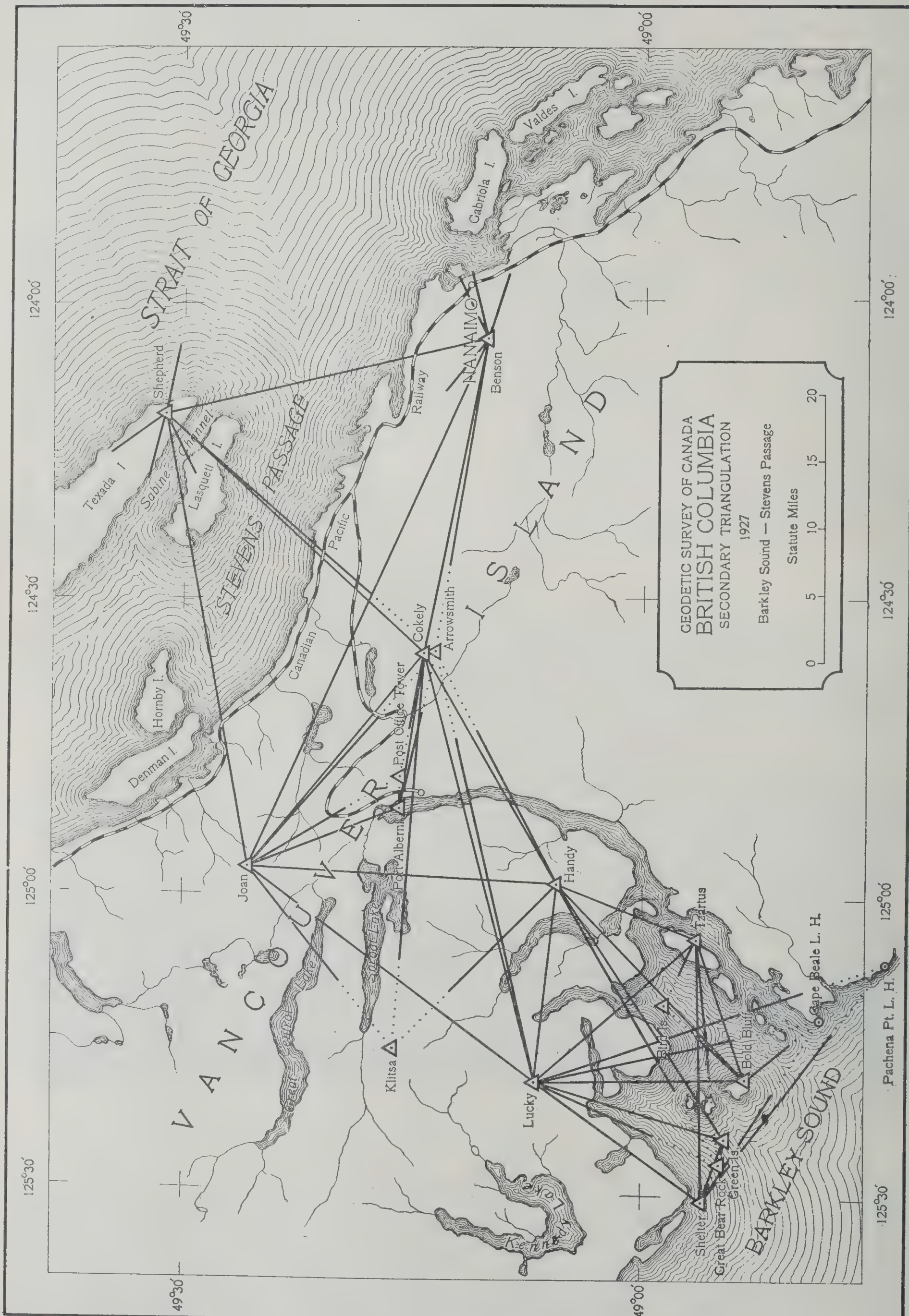
In this province the projected work includes a primary east and west net across the province from Prince Rupert to Yellowhead pass, where it will join the Alberta net, and a north and south net from Prince George via Ashcroft to Vancouver.

During 1927 a secondary net was completed across Vancouver island to the west coast at Barclay sound, at which point it forms the starting point for hydrographic and provincial triangulation nets along the west coast. It also ties in a secondary triangulation net of the Geological Survey of Canada covering much of the southerly part of Vancouver island. The latter is connected at its southerly end to primary geodetic stations south of Victoria, and with the northerly connection obtained in 1927, its results can be co-ordinated with those of the Geodetic Survey of Canada to form accurate data of great geographic value.

TRIANGULATION IN NORTHERN BRITISH COLUMBIA AND ON VANCOUVER ISLAND

Results Obtained.—In Northern British Columbia. *Reconnaissance:* 16 primary and 3 supplementary stations selected; axial length of net, 90 miles. *Station preparation*— 19 stations prepared for observing, at one of which a tower was built; axial length of net, 90 miles. *Angular measurements*—10 stations completed, 1 base line measured; axial length of net, 30 miles; area within triangulation lines, 250 square miles.

On Vancouver Island. *Station preparation*—12 secondary stations prepared; axial length of net, 72 miles. *Angular measurements*—15 secondary stations and 7 intersection stations completed; axial length of net, 72 miles; area within triangulation lines, 1,400 square miles.


GEODETIC SURVEY OF CANADA
BRITISH COLUMBIA
SECONDARY TRIANGULATION
1927
Barkley Sound — Stevens Passage
Statute Miles
0 5 10 15 20
STRAIT OF GEORGIA
STEVENS PASSAGE
VANCOUVER ISLAND
BARKLEY SOUND
Texada I.
Sabine Channel
Lasqueti I.
Hornby I.
Denman I.
Cabriola I.
Valdes I.
NANAIMO
Benson
Shepherd
Canadian Pacific Railway
Cokely
Arrowsmith
Post Office Tower
Port Alberni
Joan
Handy
Lucky
Klitsa
Sproat Lake
Great Central Lake
Kennedy L.
Bold Bluff
Cape Beale L. H.
Pachena Pt. L. H.
Shelter
Great Bear Rock
Greens
49°30'
49°00'
124°00'
124°30'
125°00'
125°30'

The program in the northern part of British Columbia was a continuation of the precise loop which has been projected through the interior of the province from Prince Rupert via Prince George and Ashcroft to Vancouver. Work was started for the season at Smithers, 227 miles east of Prince Rupert. From Prince Rupert to Smithers transportation and other difficulties dictated that the survey be carried on by the method of precise traverse, but easterly from Smithers triangulation was resumed. As a preliminary to this work, a base-line site about four miles long was selected on the right of way of the Canadian National Railway along the tangent running through Smithers station.

During the latter half of May the posts for this base line were placed, and the operation of measuring it was completed. While this work was being carried out the chief of the angular measurement party took advantage of the opportunity to locate new stations for the base net having lines cleared where necessary and monuments erected.

Angular measurements were begun about the first of July with two lightkeeping parties, and a number of signal lamps operated with time clocks. The lightkeepers were assigned to the stations which were difficult of access, and the time clocks were installed at the more accessible ones. The valley of the Bulkley river at Smithers is comparatively narrow with high, snow-capped mountains on each side, so the stations were located on the lower hills, thereby reducing the lengths of the lines. On this account the area covered by the angular measurement party during the season was small compared with the number of stations occupied. Where operations stopped for the season the valley is wider and the mountains are more accessible, so that longer lines and larger figures can be used on the 1928 work.

There was considerable rain and cool weather up to the first of July, followed by about six weeks of dry, hot weather, with excellent observing conditions. About the middle of August bush fires started and the smoke delayed operations until cleared away by the first autumn rains at the end of the month.

Looking north from station Lucky (elevation about 4,000 feet) of the Vancouver Island secondary triangulation net. The mountain in the foreground is a sister peak half a mile from the main station. This picture shows how very rough the mountain tops are and the difficulty of access to triangulation stations in this area.

The country covered by Geodetic Survey operations in 1927, known as the Bulkley valley, is chiefly a cattle ranching country. Although the country has been recently settled, a good automobile highway already runs from Hazelton to Prince George, where it connects with the Cariboo road running south to Vancouver. This highway is being extended southwest from Hazelton towards Terrace in a promising agricultural district.

On Vancouver Island, a party was engaged in preparing stations and completing the angular measurements of a secondary triangulation net extending from the primary scheme in the strait of Georgia across the island by way of Alberni and Barkley sound to the west coast. This work was undertaken to furnish control on the west coast of the island for the federal hydrographic survey, and provincial land surveys. The reconnaissance had been almost completed in 1926.

During the three months required for this survey seven stations were completed on selected mountain peaks on the island and thirteen stations on

One type of Secondary Triangulation signal used with success on Barkley Sound net on Vancouver Island. This signal was made of white canvas tacked to a wooden frame and was equally successful with a sky or dark background. With best atmospheric and background conditions it has been sighted at a distance of 34 miles. To allow a theodolite to be set up underneath it, the two lower timbers may be detached from the uprights and the canvas rolled.

small rocky islets and at lighthouses in Barkley sound. Among the former, one station is on mount Arrowsmith, one of the best known peaks on Vancouver island, with an elevation of about six thousand feet.

As elsewhere in Canada in 1927 there was a great deal of rain during the early part of the season and this with the sea fog which is so prevalent on the west coast of Vancouver island retarded the progress of observation work considerably. However, a change for the better came about the middle of July and by taking advantage of it promptly the remainder of the work was finished by the middle of August, just in time to avoid the smoke from bush fires which are usual at this season of the year.

The new, light type of transit which was used again proved its superiority for this class of work, where long pack trails and stiff mountain climbing were features. Lights were used on some lines over thirty-five miles in length but most of the angular measurements were with the use of daylight signals, rock cairns, or canvas targets, and excellent results were obtained. It was found that on well-defined mountain peaks, clear of timber and with a sky background, good results could be obtained on this class of signal up to a distance of thirty-five miles.

Primary Triangulation in Alberta and Saskatchewan

Alberta.—The projected triangulation in the Prairie Provinces includes a net northward from the International Boundary through Calgary to Edmonton and an east and west net through Edmonton, Alta., and Prince Albert, Sask. The west end of this net will eventually be joined by way of Yellowhead pass to the corresponding British Columbia net, while east from Edmonton the net will ultimately extend to the north of lake Winnipeg and east across northern Ontario. Branches from this net are required to control the Flinflon mining area of northern Manitoba and northern Saskatchewan, and also Fort Churchill and the region southward to Brandon and the International Boundary.

The projected work will not necessarily be done in the above order, but will be planned, both with regard to precedence and accuracy, to fit in with the ultimate plan.

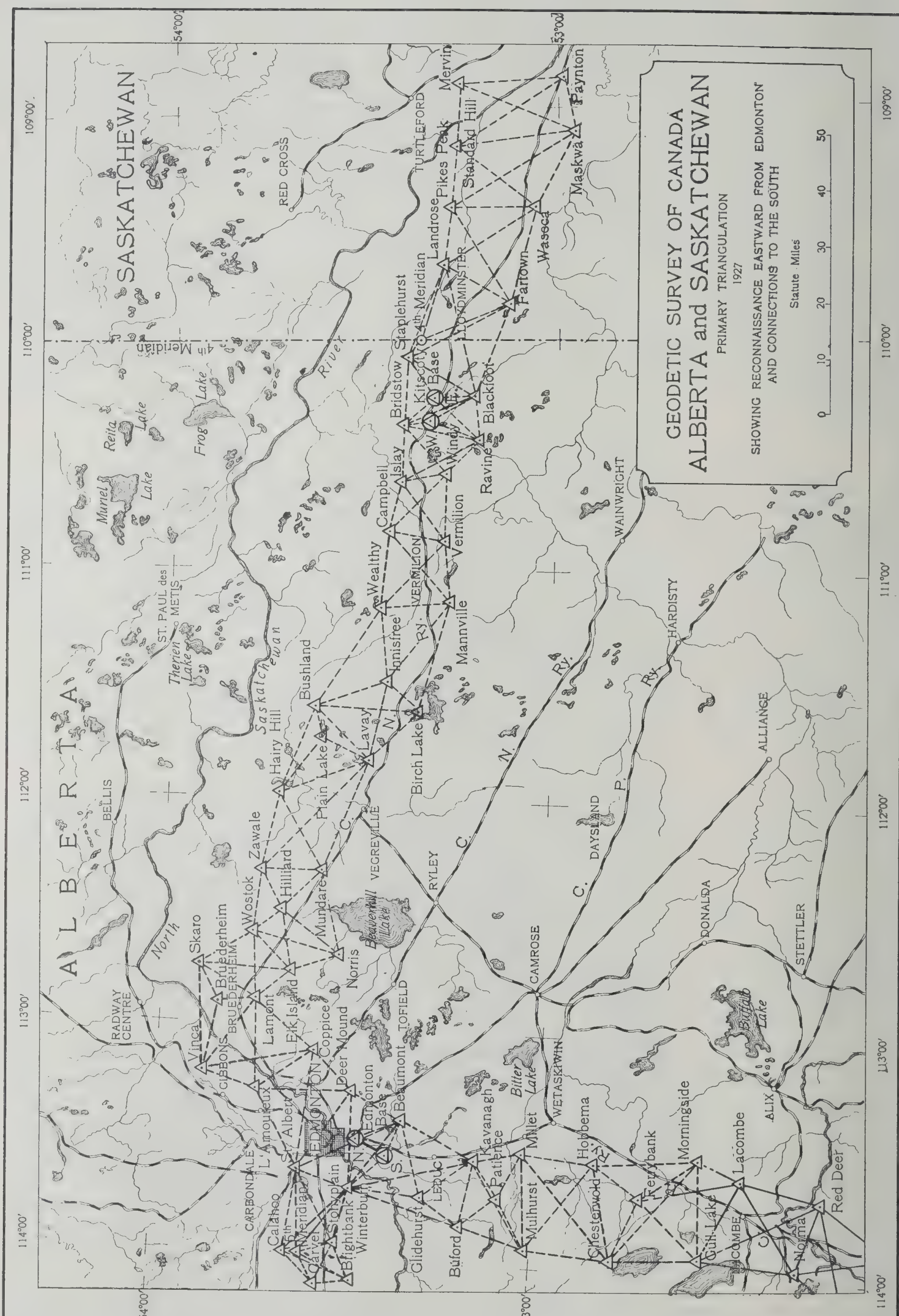
To the end of 1927 the net has been completed to a point about 50 miles south of Edmonton, while stations have been selected on the east and west net to a point 100 miles west of Edmonton and east as far as Battleford, Saskatchewan.

The net west of Edmonton as far as Yellowhead pass will be extended with greater facility after a few years when transportation conditions improve.

Results Obtained.—*Reconnaissance:* 41 stations selected; axial length of net 190 miles; 3 base lines selected. *Station preparation:* 11 standard piers built, 16 towers built, 1 other station prepared; axial length of net, 265 miles; 2 base lines prepared 15½ miles in length. *Angular measurements:* 30 main stations and 15 intersection stations completed; area within triangulation lines, 2,240 square miles; 2 base lines measured 15½ miles in length, 16 connections with land survey posts.

During the season of 1927 progress was seriously delayed by weather conditions and their effect on transportation. Rain is reported in the journal of the foreman on station preparation on forty-eight days between May 13 and September 16. On the larger portion of these days work was not stopped, but usually on succeeding days work would be delayed due to bad roads. When camped at Millet, Alberta, this party was delayed by road conditions to such an extent that by utilizing the time the lumber for four complete 60-foot towers was cut, spliced, and pieces numbered and piled in the yard before it was possible to reach any of the tower sites. The details of the parties' operations were as follows:—

Reconnaissance.—This party consisting of engineer and one assistant first selected a site for the Calgary base line, then moved to Edmonton near which a base line site was selected. Triangulation was carried eastward along the


GEODETIC SURVEY OF CANADA
ALBERTA and SASKATCHEWAN
PRIMARY TRIANGULATION
1927
SHOWING RECONNAISSANCE EASTWARD FROM EDMONTON AND CONNECTIONS TO THE SOUTH
Statute Miles
0 10 20 30 40 50
ALBERTA
SASKATCHEWAN
4th Meridian
North Saskatchewan River
EDMONTON
VEGREVILLE
CAMROSE
WETASKIWIN
LACOMBE
Red Deer
VERMILION
LLOYDMINSTER
WAINWRIGHT
HARDISTY
TOFIELD
ST. PAUL des METIS
Beaverhill Lake
Buffalo Lake
Frog Lake
Muriel Lake
114°00'
113°00'
112°00'
111°00'
110°00'
109°00'
54°00'
53°00'

Canadian National railway to the vicinity of Battleford, Saskatchewan. A base line was selected near Lloydminster.

Station Preparation.—This party consisted of a foreman and six men. The 6-mile base line at Edmonton was prepared; also the 9½-mile base line at Calgary. Towers required for triangulation between Calgary and Edmonton were built and standard piers between Edmonton and Mundare, Alta., were constructed.

Angular Measurements.—This party comprised an engineer and four men. Work was begun at Caresland—on the line Carseland-Dinton—25 miles southeast of Calgary. Upon instructions the party was transferred to the measurement of the Edmonton and Calgary base lines from June 8 to July 25, when it resumed angle measurements and succeeded in carrying this operation as far north as Lacombe, Alta.

A supplementary station with primary accuracy was established at Nose Hill to serve as control for Calgary City triangulation. Calgary is thus well enclosed by the quadrilateral, Camp-Brushy Ridge-Nose-Calgary, as the four stations named overlook the city. The sides of this quadrilateral average about ten miles in length.

A sketch of the reconnaissance in Alberta and Saskatchewan appears on page 14, while the progress of the angular measurements may be followed by referring to the sketch which appears on page 12 of the Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ended March 31, 1926.

Primary Triangulation in Ontario

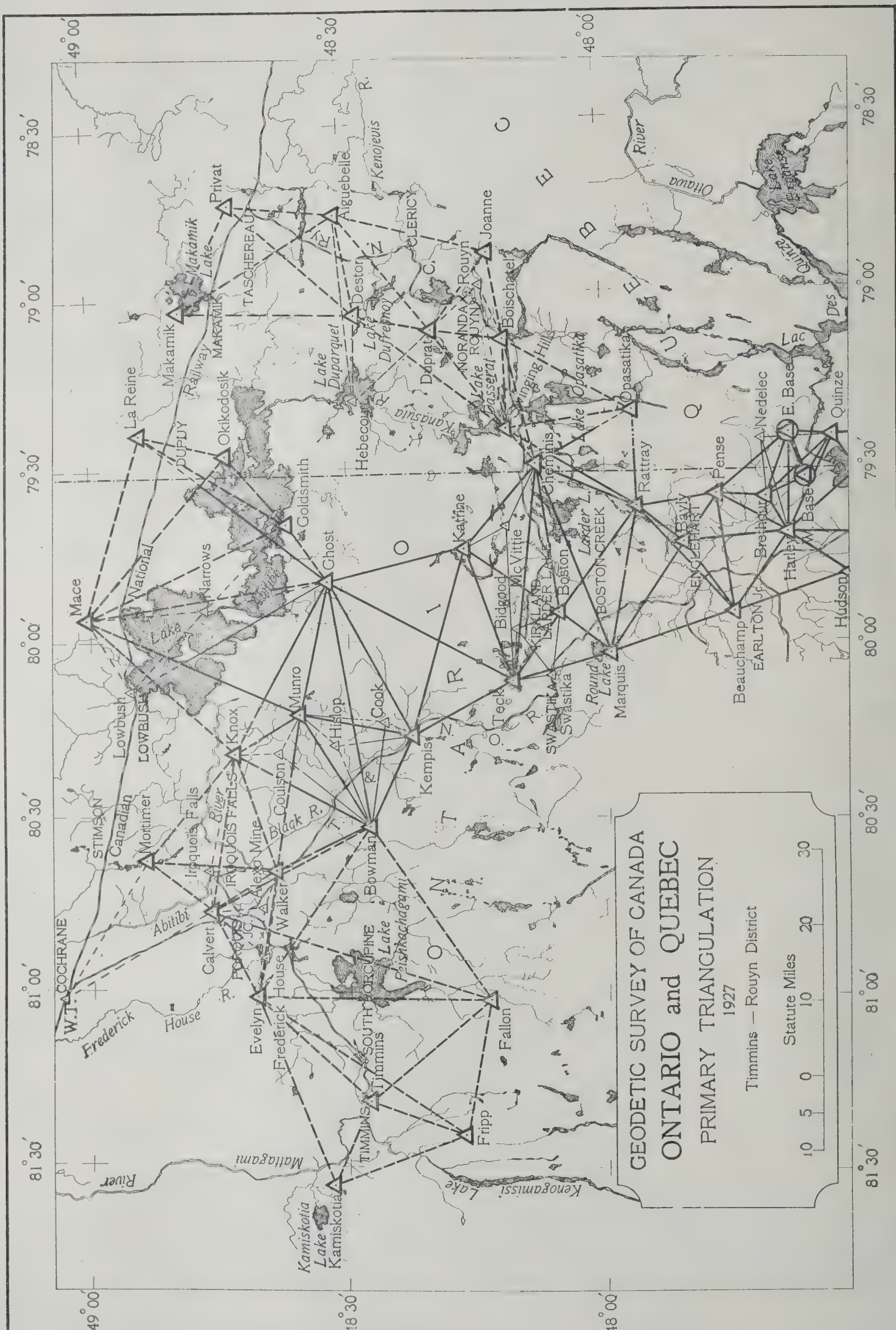
The main 1927 triangulation program in the province of Ontario was confined to the mineralized areas of northern Ontario from Kirkland Lake area north to lake Abitibi and west to the Kamiskotia district. Reconnaissance was also started to connect the Sudbury nickel area with the main net.

Projected plans for future work had to be changed during the season. The previous plan was to lay down the main triangulation net north to Cochrane, thence westward following the main line of the Canadian National railway across the province. The flat country west of Cochrane was found on examination to be quite unsuited to triangulation, so that the main net will be run westerly through Timmins to the Sudbury-Nakina branch of the Canadian National Railway, thence westerly following that line. As a control for mapping the districts adjacent to and north of the main line a precise traverse will be laid down west from Cochrane in the near future.

Results Obtained.—*Reconnaissance:* 29 primary and 11 secondary stations selected; axial length of net, 170 miles. *Station preparation:* 7 towers built, 16 primary and 14 secondary stations prepared; axial length of net, 145 miles. *Angular measurements:* 12 primary and 3 secondary stations completed, 7 intersection stations, 10 stations connected to lot corner; area within triangulation lines. 1,900 square miles.

The organization of parties was as follows: *Reconnaissance,* one engineer and one man; *Station preparation,* foreman and four men; *Direction measurement,* one engineer and five men. The engineer in charge and one man also constituted a party.

Continual rains impeded the progress of the direction measurement party in particular, as a great many nights were lost due to the lights not being visible in the rain. The same conditions made travelling very difficult for all parties, particularly the reconnaissance engineer and his assistant. Roads were soft and the bush was generally quite wet at some part of the day. Three of the assistants on the latter party had to leave the work during the season an account of illness, and the progress of the reconnaissance suffered on account of the inexperience of new men.


GEODETIC SURVEY OF CANADA
ONTARIO and QUEBEC
PRIMARY TRIANGULATION
1927
Timmins — Rouyn District
Statute Miles

Reconnaissance was carried on in four areas:—

A primary scheme was laid out westerly from the stations Mattawan and Lauder, just west of Mattawa, Ont., extending across lake Nipissing and nearly to Sudbury. The general line was astride the Mattawa river and its headwaters to the height of land, and from there astride lake Nipissing to its westerly end, from which point it turned northwesterly towards Sudbury. The lengths of lines in this scheme vary from twenty-eight miles in the easterly end to ten miles at the westerly end.

From the Ottawa river to the east of lake Nipissing high towers are required on account of the frequent occurrence of hardwood forests on prominent hills. Westward from lake Nipissing lower towers may be used, as hardwoods are largely replaced by spruce. A great part of this land is either sandy or rocky and unfit for agriculture. There are small growths of timber on areas which have been previously swept by fires.

The second area extends eastward from the primary stations Chimmis and Rattray towards the Rouyn mining area. This section of country has been mostly burned over, and transportation was limited to canoes on the lakes and streams.

In the third area a primary net was laid out extending easterly from the stations Knox and Ghost west of lake Abitibi to cover the area around lake Abitibi, projecting a few miles east of the Ontario-Quebec boundary. All the stations but two were on the limits of the Abitibi Company and were all on prominent hills in timbered country.

A fourth primary net was started westerly from the stations Bowman and Calvert, extending to the mining area west of Timmins, known as Kamiscotia. This net will likely be continued in the future across to the Sudbury-Nakina branch of the Canadian National railway and westward along that line.

The direction measurement party started the season near Englehart and worked north as far as lake Abitibi. During the first part of the season and till the work reached Kirkland lake and Ramore, canoes were the only transport that could be used. On this section of the work progress was much slower. From Matheson northerly the trucks were used on the westerly side of the work, while canoes had to be used on the easterly side, on account of the absence of roads. Nearly two-thirds of the stations were connected to township or lot corners. In many cases this required a great deal of extra work, but it was felt that these ties were worth the extra effort and expense of obtaining them.

Triangulation in this area is shown in the sketch on page 16.

Primary Triangulation and Reconnaissance in Quebec

Triangulation in various stages was carried on in four separate areas in the province of Quebec. Work on a short net was put under way along the Matapedia valley to connect the St. Lawrence River net with that at the head of Chaleur bay. This net is one of several which will be laid down in the future by both Canadian and United States geodetic surveys to subdivide the large 1,800-mile circuit of triangulation which was closed in 1925, composed of nets in the eastern section of both countries. The Matapedia net will be extended in 1928 to the centre of the province of New Brunswick.

Work was continued at both ends of the triangulation net along the transcontinental line of the Canadian National Railway across western Quebec. The western end of this net covers the whole of the Rouyn mining area and is therefore an important operation.

Reconnaissance in the Gatineau River Valley

Results Obtained.—*Reconnaissance:* 9 primary stations, 10 secondary stations and 9 topographic control points selected; axial length of net 94 miles; area within triangulation lines, 2,400 square miles.

A primary triangulation following up the Gatineau River valley northward from Ottawa has for years been part of the projected primary scheme of the Geodetic Survey of Canada in the western part of the province of Quebec. The map of Eastern Canada at the end of this report shows that this net divides into two a larger projected loop of some 900 miles circumference extending from Trois Rivières on the east to Cochrane, Ontario, on the west.

This net was commenced in 1913 as a basis for maps when a pure-water supply for the city of Ottawa from Thirtyone-mile lake was contemplated, and was carried north from Ottawa a distance of 50 miles.

In 1927 work was resumed on this net, as a basis was required for aerial mapping of the area by the Topographical Survey of the Department of the Interior. A large industrial company offered its co-operation, since it was interested not only in the mapping of the area, but also realized that the locations of the triangulation stations would provide valuable data as to the choice of sites for fire detection lookout towers.

Reconnaissance was continued from the north end of the net laid down in 1913 for a distance of ninety-five miles. Later in the season reconnaissance was started at the north end of the net near the transcontinental (Canadian National Railway) railway. Continuous rainy weather prevented a realization of the progress which had been expected and reconnaissance on the net was incomplete at the close of the season.

The country to be mapped was too wide to be covered by one net of triangulation, so the plan adopted was to lay down a net of primary triangulation along the Gatineau river with a secondary net of lower accuracy on either side as required. For mapping purposes a number of topographic control points were also selected between main stations.

Eighty-foot steel towers for fire detection purposes are being erected at seventeen of the nineteen stations selected, some primary, some secondary. Trails and telephone lines, which are a necessary complement of the fire detection system of the industrial company operating in this district, are being built. The Geodetic Survey has been granted the use of these and this will naturally facilitate the angular measurements which will complete the triangulation.

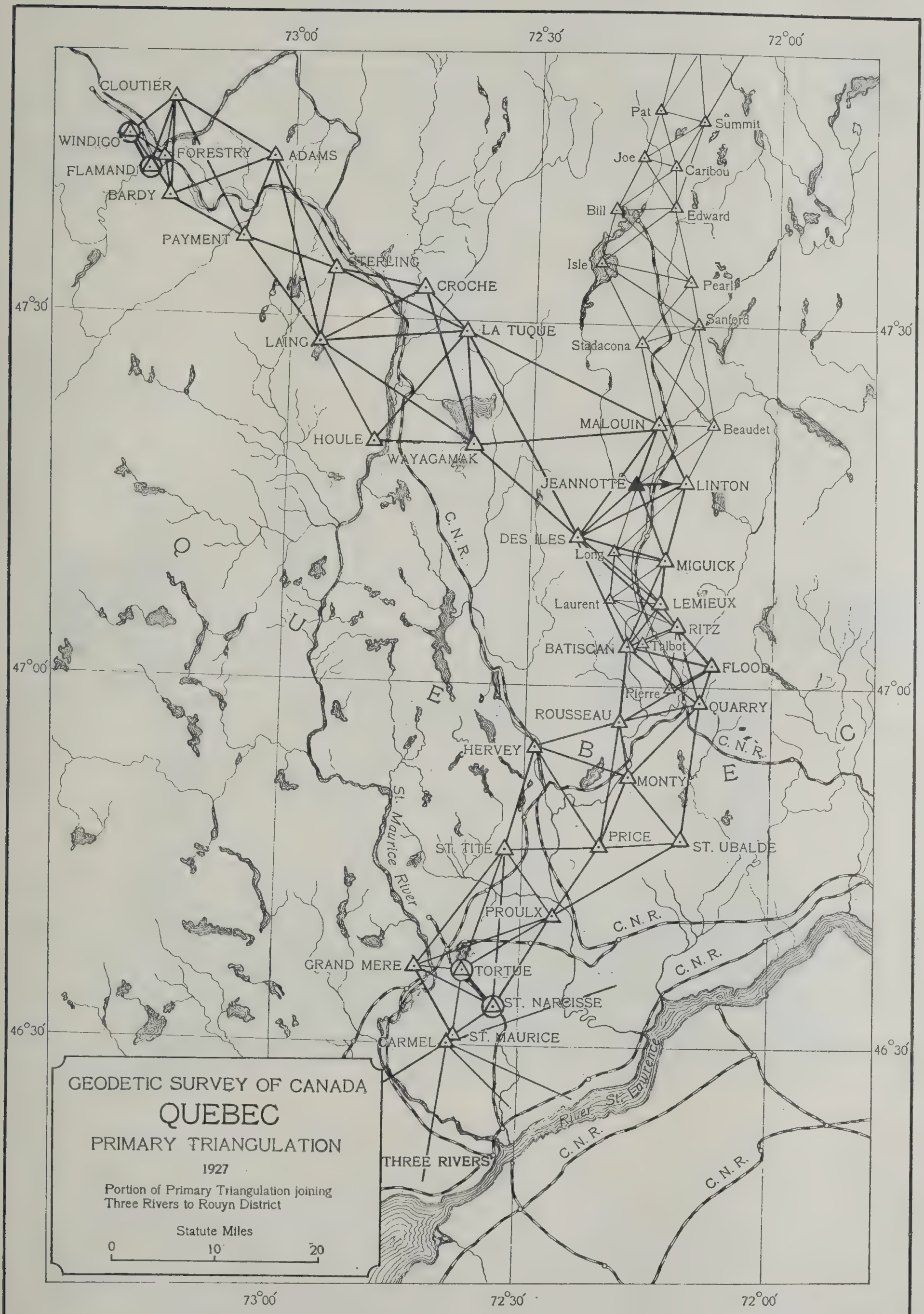
Primary Triangulation in La Tuque, Rouyn, and Lake St. John District, Quebec

Results Obtained.—In the La Tuque District—*Reconnaissance:* 5 primary stations, 1 base line and 1 Laplace station selected; axial length of net, 40 miles. *Station preparation:* 8 stations monumented (at 5 of which towers were built); axial length of net, 40 miles. *Angular measurement:* 9 primary and 4 secondary stations completed; axial length of net, 45 miles; area within triangulation lines, 380 square miles. A base line was measured by the observing party.

In the Rouyn District—*Reconnaissance:* 8 primary and 2 secondary stations selected; axial length of net, 80 miles. *Station preparation:* 6 stations monumented and towers built at three stations; axial length of net, 60 miles.

In the Lake St. John District—22 secondary stations were permanently marked by concrete monuments.

This net, though carried on in two different sections, forms a part of the projected primary net across the northern settled part of the province of Quebec illustrated in the sketch on page 19. The net starts at the main St. Lawrence River net near Three Rivers and extends north to Linton, on the Quebec and Lake St. John branch of the Canadian National railway, thence northwesterly through La Tuque. From there the projected net will continue westerly following the transcontinental line of the same railway. At a point north of the Rouyn mining district it will turn south and west through the mining area and join the extension of the Upper Ottawa River net north of lake Timiskaming in northern Ontario.


GEODETIC SURVEY OF CANADA
QUEBEC
PRIMARY TRIANGULATION
1927
Portion of Primary Triangulation joining Three Rivers to Rouyn District
Statute Miles
0 10 20
73°00′
72°30′
72°00′
47°30′
47°00′
46°30′
CLOUTIER
WINDIGO
FLAMAND
FORESTRY
ADAMS
BARDY
PAYMENT
STERLING
CROCHE
LAING
LA TUQUE
HOULE
WAYAGAMAK
Pat
Summit
Joe
Caribou
Bill
Edward
Isle
Pearl
Sanford
Stadacona
MALOUIN
Beaudet
JEANNOTTE
LINTON
DES ILES
Long
MIGUICK
Laurent
LEMIEUX
RITZ
BATISCAN
Talbot
FLOOD
Pierre
QUARRY
ROUSSEAU
HERVEY
MONTY
PRICE
ST. UBALDE
ST. TITE
PROULX
GRAND MERE
TORTUE
ST. NARCISSE
CARMEL
ST. MAURICE
THREE RIVERS
St. Maurice River
River St. Lawrence
C. N. R.
Q U E B E C

The eastern 125 miles of this 450-mile net was completed in 1927 to a point some 40 miles west of La Tuque. When the reconnaissance and station preparation parties reached this point they were moved to the western end of the projected net or loop and worked east and north through the Rouyn mining area, reaching a point near Taschereau on the Transcontinental railway (Canadian National Railway). Angular measurements were suspended for the season when the party completed the La Tuque section.

Work was carried on by three parties: a reconnaissance party consisting of an engineer and an assistant, a station preparation party comprising a foreman and four men and an angular measurement party including an engineer, assistant engineer and four men.

Rain and fog considerably hampered the work of all parties, the angular measurement party in particular. In the short season of 131 days the latter lost 50 days owing to these causes.

The reconnaissance party started at Stirling, about twelve miles west of La Tuque, and carried the work as far west as Windigo where a base line and Laplace station were selected. From there they moved to the Rouyn district and connecting with the Upper Ottawa River net, worked east and north as far as Taschereau on the transcontinental line of the Canadian National Railway.

The station preparation party also started at Stirling, and, after completing the stations as far as Windigo, moved to the Rouyn district where they prepared all stations to a point about fifteen miles south of Taschereau.

The angular measurement party started at Houle about twelve miles southeast of La Tuque and completed the observing up to and including the Laplace point at Windigo. This party also assisted in the measuring of the base line.

After the main operations were completed for the season, the station-preparation party moved to the Lake St. John district and permanently marked twenty-two secondary stations which had been used in that area.

The triangulation in the La Tuque area is shown on the sketch on page 19, and that in the Rouyn mining district on the sketch on page 16.

GEODETIC ASTRONOMY AND ISOSTASY

Geodetic Astronomy

During the field season of 1927, Laplace observations were made at six of the observing stations of the Geodetic Survey of Canada. Five of these stations, Haysport, Martin, Lorne, Skeena Crossing and East Base at Smithers, are on the precise traverse line in British Columbia along the Canadian National railway between Prince Rupert and Smithers for the purpose of azimuth control. The other Laplace observation was made at Windigo to furnish control of the azimuth of the Quebec triangulation net. The broken telescope type of transit shown on page 21 was used in these operations.

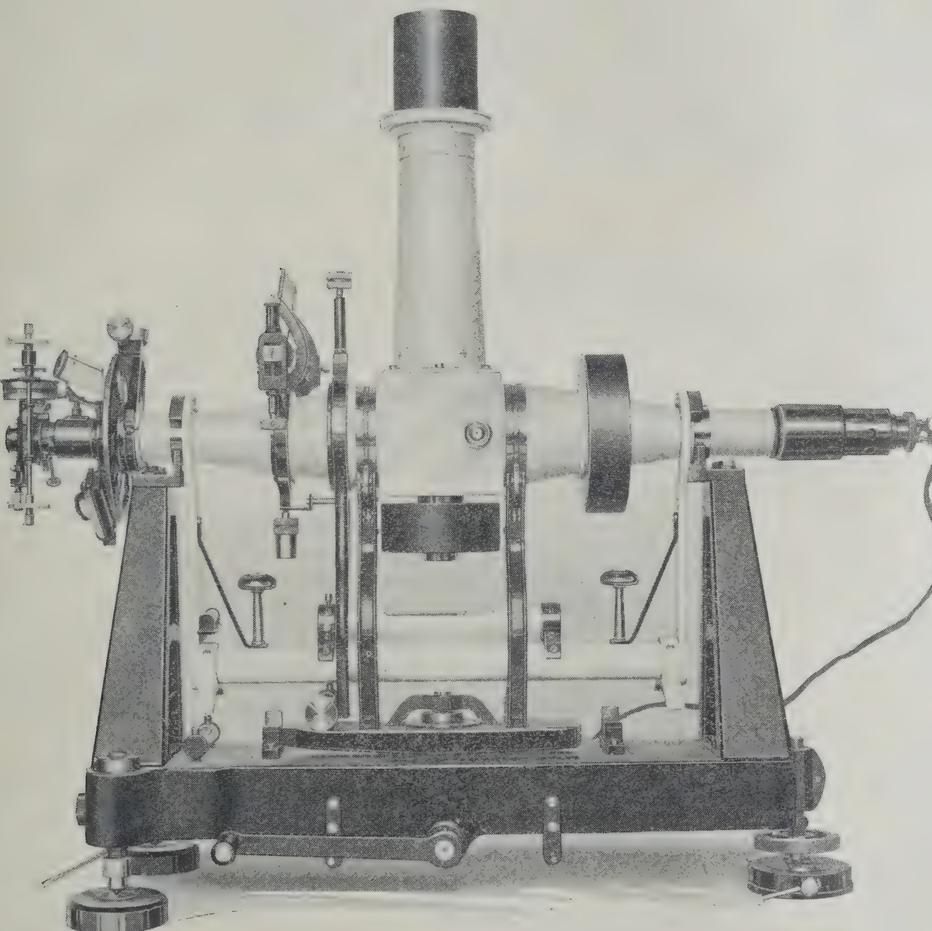
Standards

This work consisted in the standardizing of the invar base line tapes used in base line measurement, and of the level rods used in the Precise Level division of this survey. The results from the determinations of the lengths of these base line tapes show the continued need of their frequent standardization if the required degree of accuracy in the length of the base lines is to be attained. Three of the base lines measured were in Western Canada. To return to Ottawa with the tapes for standardization between base operations would have been very expensive. To obviate this, three of the microscopes used in the standards' work were taken to the field where the three base line tapes were carefully

inter-compared. From these inter-comparisons any change of even a small magnitude would have been detected. Careful standardization from the standard metre bar was made before and at the end of the season.

Base Lines

Control for the scale of length of several nets of triangulation was provided by the measurement of four base lines, one in British Columbia near Smithers, two in Alberta, near Edmonton and Calgary respectively, and a fourth in Quebec near Windigo.



Transit of the broken telescope type used by the Geodetic Survey of Canada.

Isostasy

For some time past it has been the desire of the Director of the Geodetic Survey of Canada that an energetic campaign of longitude and latitude observations should be inaugurated to determine the deviation of the vertical, such observations to be used in the study of Isostasy. With that end in view twelve of the Geodetic triangulation stations in Ontario were occupied for longitude and latitude, namely, Elizabethtown, Emily, Warwick, Hullet, Portland, Scarboro, Brock's Monument, Dumphries, Deerbrook, Orford, Elsinore and Oro.

The field work under this heading consists in the observing of the astronomical longitude and latitude at the triangulation stations of the Geodetic Survey. From the comparison of the results obtained with the true position as given by the adjusted geodetic values, the errors of the deflection of the vertical are obtained. These deflections are eliminated in part by the attraction of the topography on the surface of the earth surrounding the station. But it is found that if the deflection of the vertical at a station is corrected for the topography surrounding the station the total correction for the effect of the topography is greater than the observed deflection of the vertical.

Material is available at the present time from nearly one hundred stations, and a start has been made in this investigation. In the course of the next year or so, it is hoped that much valuable information will be procured, and made available for a determination of the size and shape of the earth from Geodetic Survey observations. Canada, occupying as it does a large part of the North American continent, will no doubt furnish much valuable information to all engaged in the study of Isostasy.

LEVELLING

During the year a general revision of the records of precise level bench marks has been made for the purpose of publication. There will be separate publications, each containing the bench marks in a certain geographical division. One publication will include the Maritime Provinces; two will be required for each of the provinces of Quebec and Ontario, and one publication for each of the four western provinces. These nine publications will contain, in all, about 7,340 bench marks which have been established along 22,000 miles of precise levelling. The various groups are being dealt with in order from east to west. The manuscripts for publications covering the Maritime Provinces, and for those covering the two divisions of Quebec, are now completed, and considerable work has been done on manuscripts for the two Ontario publications.

The records of elevations compiled from the profiles of the various railways have steadily increased. During the year 138 rolls of profiles covering 2,800 miles of railway were received, making a total to date of 482 rolls covering 10,770 miles. Nearly all of this mileage is in the western provinces. The list of every new branch railway is compiled as soon as its profile can be obtained, which is usually immediately after construction. Elevations are taken from the profiles at every station and road crossing and at all other salient points, so as to average about three records per mile. These records are individually adjusted to the datum of mean sea level and are then typed in a form convenient for reference. At the end of the year records covering 7,800 miles of railway levelling had been compiled in this way, adjusted, and typed in final form. It has been found that the railway levelling is, in itself, remarkably accurate, but the variety of datums used requires adjustment of a complex nature. When such adjustment has been applied separately to each branch line, the results obtained from one branch nearly always agree with the results from another branch. Although the field work of railway levelling has been accurate, there has heretofore been an almost entire absence of any attempt to co-ordinate its results to a standard datum.

There have been many enquiries from outside sources for information regarding elevations and all such enquiries have been answered as fully as possible.

A considerable amount of work is always going on in adjusting elevations of groups of secondary and tertiary levelling through which new lines of control levelling have recently been run. Such readjustment is always very complex, and requires much care so as to avoid needless disturbance of previous records for the sake of unimportant corrections.

The main activities in the field were the inspection of old bench marks and the construction of Fundamental bench marks.* Both these operations were carried out on an augmented scale during the past season, a special party being assigned to each.

An innovation in the field procedure in 1927 was the use of the Zeiss pattern instrument for certain lines of precise levelling in place of the standard instrument of the United States Coast and Geodetic Survey pattern, which until 1927 had been used for all precise levelling by this Survey since the inception of the work. The Zeiss pattern level (see illustration inside the front cover) was used on one line in Quebec and one in British Columbia, and was found to give satisfactory results as indicated by the closure of forward and backward measures within the prescribed limits. It possesses certain advantages over the other type of instrument in portability and rapidity of setting up.

Besides the two special parties above noted, three regular parties were in the field—one in the Province of Quebec, occupied in precise and secondary levelling, one in British Columbia and one on the prairie, partly in Manitoba and partly in Saskatchewan. The activities of the two western parties were confined entirely to precise levelling.

Levelling in the Province of Quebec

One party operated during the whole season in the Province of Quebec, the first work undertaken being the completion of the line of secondary levels along provincial highway No. 5 from Tring Junction to Sherbrooke. These levels had been carried from Levis as far as Tring Junction in 1926. On the completion of this work the party moved to Ste. Therese and ran precise levels along the Canadian Pacific railway through the Laurentians to mont Laurier, continuing with secondary levels along provincial highway No. 30 to Maniwaki, at which point a closure was made on the precise level line along the Canadian Pacific railway from Ottawa.

At Maniwaki the party was disbanded and the engineer proceeded to Montreal about the middle of September to complete the special levelling in the city and surrounding district, which was commenced in 1926. One hundred and ninety-seven additional concrete monuments (combined bench marks and triangulation stations) had been constructed by the Corporation of Montreal during the summer and were now connected by precise levelling, this work being completed shortly after the first of December.

The Montreal levelling was carried out under the same co-operative arrangement followed in the previous year, whereby the corporation paid for the subsistence of the engineer and provided whatever assistants were required, together with automobile transport, so that practically the only expense incurred by the Geodetic Survey of Canada was the salary of the engineer for the time he was engaged on the special work. The city of Montreal is now in possession of a most complete system of precise level control, consisting of 651 bench-mark monuments which cover the whole lower portion of Montreal island from Montreal West to the foot of the island, and extend northward to the rivière des Prairies.

Levelling in the Province of Ontario

A special party consisting of an engineer and one assistant spent the summer in constructing Fundamental bench marks at certain selected points in central and southwestern Ontario. These monuments, together with those constructed in 1925 and 1926, will be the governing bench marks for the most

*A full description of the Fundamental bench marks and the principles guiding their location will be found in the Report of the Director of the Geodetic Survey of Canada for the fiscal year ended March 31, 1926.

populated portion of Ontario and it was considered to be a matter of importance that they should be constructed in time to be included in the Southern Ontario levelling publication, the manuscript for which was prepared in the winter of 1927-28. On this account it was decided to have one engineer concentrate on the building and tying in of these monuments.

The actual construction—excavation, concrete work, backfilling and finishing—was carried out at each place by contract or by day labour employed locally, and cost, for labour and materials, slightly over fifty dollars apiece on the average. All the monuments were constructed in places through which precise levels had previously been run, so that no major levelling operations were involved in determining their elevations; however, the recovery of the old levels and the careful levelling to each monument required quite an appreciable amount of instrumental work in the course of the summer. This was carried out by the engineer and his assistant, together with local help, during and after the construction of each monument, as opportunity offered. A light delivery truck was used for transportation and for carrying instruments, tools, etc. It was found most economical to construct the monuments in pairs, or in groups of three, wherever practicable, to enable the engineer to supervise the work.

Monuments were constructed at the following places: Brantford, Chatham, Galt, Goderich, Guelph, Hamilton, Kitchener, Lindsay, Orangeville, Orillia, Oshawa, Owen Sound, Palmerston, Peterboro, Parkhill, St. Catharines, Sarnia, Stratford, Welland, Windsor, Wingham and Woodstock.

Levelling in the Provinces of Manitoba and Saskatchewan

Two precise level lines were run, each of the lines lying partly in Manitoba and partly in Saskatchewan and intersecting one another at Canora, Sask. One line extended from Yorkton, Sask., to Swan River, Man., and the other from Dauphin, Man., to Margo, Sask., both following Canadian National railway lines. The large precise level circuit—nearly 1,000 miles in perimeter—which extended from Prince Albert through Hudson Bay Junction, Swan River, Dauphin, Portage la Prairie, Minnedosa, Yorkton, Colonsay and thence to Prince Albert, was broken up by these lines into four circuits of more reasonable size and precise levelling control was furnished to an area previously somewhat deficient in this respect.

Fundamental bench marks were constructed at Canora, Dauphin, Swan River and Yorkton.

Levelling in the Province of British Columbia

One party was engaged in precise levelling in this province throughout the summer. At the first of the season two short lines were run in the Okanagan district, one from Vernon to Kelowna and the other from Armstrong north-westerly along the Canadian National railway to its junction with the Canadian Pacific railway at Bostock, about eleven miles east of Kamloops. From this point the party moved to Ashcroft and ran levels along the Cariboo road to Clinton, on the Pacific Great Eastern railway, a distance of thirty-three miles; suspending operations at Clinton they moved to Squamish, at the head of Howe sound and began a line of levels from that point along the above-mentioned railway through Clinton to Prince George, the levels being based on the tidal gauge of the Department of Marine and Fisheries. At the close of the season the levels had reached a point on the railway some eighty-four miles from Clinton.

Fundamental bench marks were constructed, during the course of the levelling operations, at Armstrong and Kamloops.

Inspection of Bench Marks

This work, in the past carried on largely as an incidental to supervisory trips and other field operations, received an impetus in 1927 in an effort to complete an inspection of all Geodetic Survey precise level bench marks preparatory to issuing their latest description and elevations in a series of publications.

The special inspection party consisted of an engineer and one railway employee, travelling on a railway motor car and securing living accommodation at hotels and boarding houses along the lines inspected. This party started on the Toronto-Sudbury line of the Canadian Pacific railway and operated in northern Ontario, Manitoba and the easterly portion of Saskatchewan. In addition to this the engineer in charge of the Prairie levelling party assisted at the close of the season with certain lines in these provinces and the Supervisor of Levelling continued his inspection in central and southwestern Ontario and in parts of Manitoba. The lines inspected in 1927 aggregated some 5,100 miles in length and included 1,546 bench marks. Of this number, 116, or about 7½ per cent were found to have been destroyed.

The following is a detailed statement of the levelling run in 1927: —

Line	On Railway	Off Railway	Total
	miles	miles	miles
Precise Levelling—			
Ste. Therese to Mont Laurier, P.Q	138·2	1·4	139·6
Montreal District lines, P.Q	0·0	82·0	82·0
Yorkton, Sask., to Swan River, Man	119·5	1·5	121·0
Dauphin, Man., to Margo, Sask	165·0	0·9	165·9
Vernon to Kelowna, B.C	33·5	0·5	34·0
Armstrong to Bostock, B.C	56·7	0·0	56·7
Ashcroft to Clinton, B.C	0·0	33·0	33·0
Squamish to D'Arcy, B.C	82·8	0·0	82·8
	595·7	119·3	715·0
Secondary Levelling—			
Tring Junction to Sherbrooke, P.Q	0·0	84·5	84·5
Mont Laurier to Maniwaki, P.Q	0·0	37·3	37·3
	0·0	121·8	121·8

Summary by Provinces for 1927

Province	Mileage levelled	Bench mark piers built	Total bench marks established
Precise Levelling—			
Quebec	222*	....	79
Ontario	....	23	28
Manitoba	101	19	31
Saskatchewan	186	39	69
British Columbia	206	33	89
	715	114	296
Secondary Levelling—			
Quebec	122	5	54

*This includes the 82 miles run in the Montreal district, but the bench marks—197 in number—have not been included in the summary as they are not of the standard type used by the Geodetic Survey of Canada.

GENERAL SUMMARY

	Miles	Bench marks
Precise Levelling—		
Prior to 1927	22,660	7,650
1927	715	296
Totals	23,375	7,946
Secondary Levelling—		
Prior to 1927	9,308	2,917
1927	122	54
Totals	9,430	2,971

The mileage of precise and secondary levelling in each province is as follows:—

Province	Precise Levelling			Secondary Levelling		
	Prior to 1927	1927	Total	Prior to 1927	1927	Total
Nova Scotia	729	....	729	....	....	....
New Brunswick	1,096	....	1,096	....	....	....
Quebec	2,843	222	3,065	47	122	169
Ontario	5,689	....	5,689	....	....	....
Manitoba	2,162	101	2,263	368	....	368
Saskatchewan	3,919	186	4,105	5,098	....	5,098
Alberta	2,866	....	2,866	3,795	....	3,795
British Columbia	2,803	206	3,009	....	....	....
Yukon	458	....	458	....	....	....
Minnesota, U.S.A.	89	....	89	....	....	....
Vermont, U.S.A.	6	....	6	....	....	....
Totals	22,660	715	23,375	9,308	122	9,430

The mileage of *precise levelling* along each of the railways is as follows:—

Railway	*Miles*
Canadian National	11,560
Canadian Pacific	7,444
Kettle Valley	364
Timiskaming and Northern Ontario	320
Algoma Central	319
Alberta and Great Waterways	282
Great Northern	230
Edmonton, Dunvegan and British Columbia	170
Quebec Central*	149
Dominion Atlantic	146
Pacific Great Eastern	92
White Pass and Yukon	91
Temiscouata	82

Railway	*Miles*
New York Central	55
Pere Marquette	55
Maine Central	36
Roberval and Saguenay	31
Napierville Junction	28
British Columbia Electric	28
Quebec Railway, Light and Power Co.	25
London and Port Stanley	24
Alma and Jonquiere	16
Maritime Coal, Railway and Power Co.	12
Michigan Central	3
Highways and cross-country levels	1,813
	23,375

*Including Boston and Maine Railroad line from Lennoxville, Que., to Newport, Vt., recently taken over by Quebec Central Railway.

MATHEMATICAL RESEARCH

The work done in this Division has for its object the devising of scientific means to control and regulate the distortion which comes into triangulation nets due to the great distances surveyed in a country the size of Canada. By reducing this distortion within probable limits, taking account of the peculiar topographical conditions of the country, the work of the Geodetic Survey of Canada is placed on a reliable basis.

At the present time there is being developed a theory that will make it possible to combine traverses and triangulation work as a whole. This will be particularly useful in British Columbia, where, due to the mountainous nature of the country, traverses have been completed, followed up by triangulation work. This combination is also being made use of in northern Ontario.

Up to the present time no means have been devised of determining what is the real accuracy of combined traverses and triangulation work.

The following investigational works have been completed:—

Precise Traverse

This is a new subject, and the theory which shows its application will enable the engineer to make use of the latitudes and departures of previous surveys and, within the limits of their accuracy, turn them into geodetic data allowing for the correction due to the shape of the earth.

The whole method of the conversion of latitudes and departures to true latitudes and longitudes and the advantages derived therefrom have been outlined in a publication which will be Publication No. 25 of the Geodetic Survey of Canada. This should prove valuable to engineers who have been confronted with the difficulty of adjusting plane traverses to geodetic traverses allowing for the curvature of the earth.

Differential Method of Adjustment

This method has been explained and illustrated in a manuscript which is almost ready for publication. The method has been applied with the greatest advantage to work of the Geodetic Survey of Canada, as by it, only, the effects of bases and Laplacian points on geodetic work can be found. It also enables one to note exactly the effect of new work upon that of previous years. This method has been the subject of considerable enquiry from engineers desirous of knowing the actual effect on previous work of new work executed yearly.

Geodesy

The distribution of the treatise, Geodesy, Publication No. 11, was effected during the year, and it has been in the hands of the public for some months. The reception by the engineering public has been very favourable.

PRECISE LEVELLING ADJUSTMENTS AND PRECISIONS

The ninth adjustment of the precise level net of Canada was completed during the year. A short tabulation of these adjustments will explain just what each contains.

Adjustment No. 1. All Canadian precise levels up to the year 1921 based on Atlantic datums only, namely, tidal stations at Halifax, Yarmouth and Father Point.

Adjustment No. 2. Same as Adjustment No. 1, with conditions added introducing Pacific datums at Vancouver and Prince Rupert.

Adjustment No. 3. Condition added by breaking up large circuit—Edmonton, Lacombe, Alix, Tofield, Edmonton—by a line from Camrose to Wetaskiwin.

Adjustment No. 4. Addition of work of season 1922—bringing in four new conditions.

Adjustment No. 5. Addition of work of season 1923—introducing three new conditions by breaking up large circuit in New Brunswick and including a new line in Northern Ontario.

Adjustment No. 6. This adjustment involved all the Canadian precise levelling up to the year 1924 and an additional seventeen conditions obtained by the inclusion of United States and United States-Canada levelling along the eastern International Boundary.

Adjustment No. 7. All Canadian work in adjustment No. 5 and two new conditions formed by a new line running from Cochrane to Harvey Junction.

Adjustment No. 8. All levelling in adjustment No. 7 plus the U.S. and U.S.-Canadian border levelling mentioned in adjustment No. 6.

Adjustment No. 9. Includes with all levelling in seventh adjustment a number of new conditions in British Columbia as well as a number of conditions brought in by inclusion of lake levels.

In each case the successive adjustments were made as differentials over the preceding, so that every adjustment was a complete net adjustment, at the same time showing the effect of the new conditions introduced.

TRIANGULATION ADJUSTMENTS AND PRECISIONS

Eastern Canada

The chief advance in the Triangulation Adjustment Division during the past year has arisen from problems in connection with circuit closures in large loops. In eastern Canada an 1,800 mile circuit requires to be adjusted so that each of the five large nets, into which the total has been divided for suitable handling, will receive its proportionate share of the adjustment. Arbitrary methods of assigning the amounts for each net are not suitable as the probable strengths of the individual nets are not equal. A strict method of assigning these various amounts has been evolved and the elimination of the closure is now in process for the entire eastern work. The first net eastward from Montreal for about 250 miles has been adjusted.

British Columbia Coast Net

The new adjustment of the triangulation nets in the western part of the United States carried out by the United States Coast and Geodetic Survey altered considerably the positions of points on which our British Columbia Coast survey was based. It was therefore necessary to readjust the British Columbia triangulation to correspond therewith and incidentally to provide an accurate basis on which the Alaskan triangulation could be placed. This has been accomplished and the determination of these corrected positions is nearing completion.

Northern Ontario

The requests for information on positions of points in northern Ontario have been met as early as possible by the adjustment of all work in that section. The adjustment is dependent on the old Ontario net. This part of the work was particularly required for the provincial engineers in Toronto, the important developments in this section during the last few years making it necessary to have accurate surveys.

Western Ontario

The adjustments of all the western Ontario nets are complete and include all primary and secondary points. A comprehensive publication is being prepared which will contain a description of the methods employed, and a full

tabulation of the positions of all geodetic points with comments on the accuracy of the results. This should prove a very valuable publication to all engineers in Ontario.

Secondary stations, lighthouses and church spires are being evaluated in areas where there are demands for such information. In this connection a complete net from Halifax along the southwest coast of Nova Scotia to Liverpool and thence northward halfway to the bay of Fundy has been adjusted to control topography of the Geological Survey, Mines Department and Topographical Survey, Department of the Interior. Also a chain of secondary triangulation across Vancouver island has been adjusted for the Surveys Division of the Lands Department of British Columbia.

Reduction of British Columbia Precise Traverse

The adopted lengths and approximate bearings of the courses from Newton to Smithers were first determined from the field data. This section of the precise traverse in northern British Columbia comprises 496 courses with several auxiliary courses and 23 azimuth stations. Preliminary geodetic positions for these stations were worked out. These positions were based upon the values obtained from Newton, the terminal point of the traverse in the previous year. The accuracy of the evaluations was established by determining the geodetic position of the last station of the traverse making use of the theory recently evolved for the conversion of latitudes and departures to geodetic latitudes and longitudes. The geodetic positions of all stations on this traverse are in the course of being transferred to a new origin corresponding to the change in position of the fundamental stations of the British Columbia Coast triangulation.

Information Bureau

All field data of the season 1927 have been catalogued as well as positions and elevations resulting from the adjustments of various nets of triangulation and levelling. These adjustment results include a large number of positions of reference points, etc., in western Ontario, and also new positions for all points along the British Columbia coast. There has been an unusually large number of requests for information from engineers engaged on government, municipal and corporation work.

LOCALITY OF FIELD OPERATIONS OF THE GEODETIC SURVEY OF CANADA DURING THE FISCAL YEAR ENDED MARCH 31, 1928

TRIANGULATION

Northern British Columbia	Primary Triangulation—reconnaissance, angular measurements, station preparation and tower building.
Vancouver Island, B.C.	Secondary Triangulation—reconnaissance, angular measurements, station preparation.
Alberta and Saskatchewan	Primary Triangulation—reconnaissance, angular measurements, station preparation and tower building.
Northern Ontario	Primary Triangulation—reconnaissance, angular measurements, station preparation and tower building.
Northern Quebec	Primary Triangulation—reconnaissance, angular measurements, station preparation and tower building.
Gatineau Valley, Que.	Reconnaissance.
Nova Scotia and Matapedia Valley, Que.	Primary Triangulation—reconnaissance, angular measurements, station preparation and tower building.

Geodetic Astronomy, Isostasy and Base Lines

British Columbia	Laplace stations and base line measurement.
Alberta	Base line measurement.
Western Ontario	Isostasy investigations.
Northern Quebec	Laplace stations and base line measurement.

Levelling

British Columbia	Precise levelling.
Saskatchewan	Precise levelling and inspection of bench marks.
Manitoba	Precise levelling and inspection of bench marks.
Ontario	Inspection of bench marks and construction of fundamental bench marks.
Quebec	Precise and secondary levelling.

LIST OF PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA

Publication No. 1—Precise Levelling—Certain lines in Quebec, Ontario and British Columbia.

Publication No. 2—Adjustment of Geodetic Triangulation in the provinces of Ontario and Quebec.

Publication No. 3—Determination of the Lengths of Invar Base Line Tapes from Standard Nickel Bar No. 10239.

Publication No. 4—Precise Levelling—Certain Lines in Ontario and Quebec.

Publication No. 5—Field instructions to Geodetic Engineers in charge of Direction Measurement on Primary Triangulation.

Publication No. 6—(Withdrawn from publication as levelling contained is republished in Bulletins).

Publication No. 7—Geodetic Position Evaluation.

Publication No. 8—Field instructions for Precise Levelling.

Publication No. 9—The Making of Topographical Maps of Cities and Towns, the First Step in Town Planning.

Publication No. 10—Instructions for Building Triangulation Towers.

Publication No. 11—Geodesy.

Publication No. 12—Mathematical Statistics of the Geodetic Survey of London Ont. (Distributed by the City Engineer at London, Ont.)

Publication No. 13—Errors of Astronomical Positions Due to Deflection of the Plumb Line.

Publication No. 14—Levelling. Co-ordination of Elevations of Bench Marks in the City of Calgary, Alberta.

Publication No. 15—Levelling. Bench Marks Established along Meridians, Base Lines and Township Outlines in Saskatchewan.

Instructions to Lightkeepers; Use of Electric Signal Lamps, being Appendix No. 4 to Publication No. 5.

Publication No. 16—Levelling. Precise Levelling in Nova Scotia, New Brunswick and Prince Edward Island.

The Geodetic Survey of Canada; Operations, April 1, 1912, to March 31, 1922—Publications of the International Geodetic and Geophysical Union, Rome, 1922.

Reports of the Section of Geodesy: The International Geodetic and Geophysical Union. Second General Conference, Madrid, 1924; Operations of the Geodetic Survey of Canada,: April 1, 1922, to March 31, 1924.

Reports of the Section of Geodesy, The International Geodetic and Geophysical Union, Third General Conference, Prague, 1927, Operations of the Geodetic Survey of Canada. April, 1924, to December, 1926.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1918.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1919.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1920.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1921.

Annual Report of the Superintendent of the Geodetic Survey of Canada for the fiscal year ending March 31, 1922.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1923.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1924.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1925.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1926.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1927.

Annual Report of the Director of the Geodetic Survey of Canada for the fiscal year ending March 31, 1928.

LIST OF PUBLICATIONS OF THE GEODETIC SURVEY OF CANADA—*Concluded*

Precise Levelling Bulletins

Bulletin A—
Vancouver, B.C., and adjacent district—as far east as Mission, Matsqui and Huntingdon.

Bulletin B—
Abbotsford to Resplendent, B.C.
Spences Bridge to Brodie, B.C.
Mission to Hope, B.C.

Bulletin C—
Saskatoon, Sask., to Prince George, B.C.
Prince Rupert to Prince George, B.C.

Bulletin D—
Calgary, Alta., to Kamloops, B.C.
Revelstoke to Arrowhead, B.C.
Sicamous to Okanagan Landing, B.C.

Bulletin E—
Kipp, Alta., to Golden, B.C.
Bull River to Kootenay Landing, B.C.

Bulletin F—
Calgary to Lethbridge, Alta.
Calgary to Tofield, Alta.
Camrose to Wetaskiwin, Alta.

Bulletin G—
Moose Jaw, Sask., to Coutts, Alta.
Swift Current, Sask., to International Boundary.

Bulletin H—
Irricana to Medicine Hat, Alta.
Bassano, Alta., to Swift Current, Sask.
Empress to Compeer, Alta.
Kerrobert to Unity, Sask.

Bulletin I—
Stephen, Minn., to Regina, Sask.
Regina to Prince Albert, Sask.

Bulletin J—
Napinka to Neepawa, Man.
Minnedosa, Man., to Regina, Sask.
Yorkton to Saskatoon, Sask.
Colonsay to Prince Albert, Sask.
Lanigan, Sask., to Brandon, Man.

Bulletin K—
Emmerson, Man., to Port Arthur, Ont.
Sprague to Neepawa, Man.
Portage-la-Prairie to Plum Coulee, Man.

Bulletin L—
Winnipeg, Man., to Kenora, Ont.
Winnipeg to Victoria Beach, Man.

Bulletin M—
Rennie, Man., to Armstrong, Ont.
Superior Junction to Rowan, Ont.

Bulletin N—
Sudbury to Cochrane, Ont.
Armstrong to Cochrane, Ont.

Index Bulletin, Precise Levelling.
Precise Level Lines of the Geodetic Survey of Canada in the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba, and in the northern portion of the province of Ontario, north and west of North Bay.

Copies of the above publications may be obtained by applying to the Director of the Geodetic Survey of Canada, Ottawa.

Department of the Interior
SURVEY OF CANADA
DIRECTOR
MAP
OF
EASTERN CANADA
SHOWING
CONDITION OF FIELD OPERATIONS
AT END OF YEAR
1927
Scale 1:3,801,600 or 60 Miles to 1 inch
50 0 50 100 150
LEGEND
Astronomic Stations Latitude
Longitude
James
Bay
QUEBEC
GULF OF ST LAWRENCE
RIVER ST LAWRENCE
ATLANTIC OCEAN
SUPERIOR
HURON
ONTARIO
ERIE
TORONTO
NEW YORK

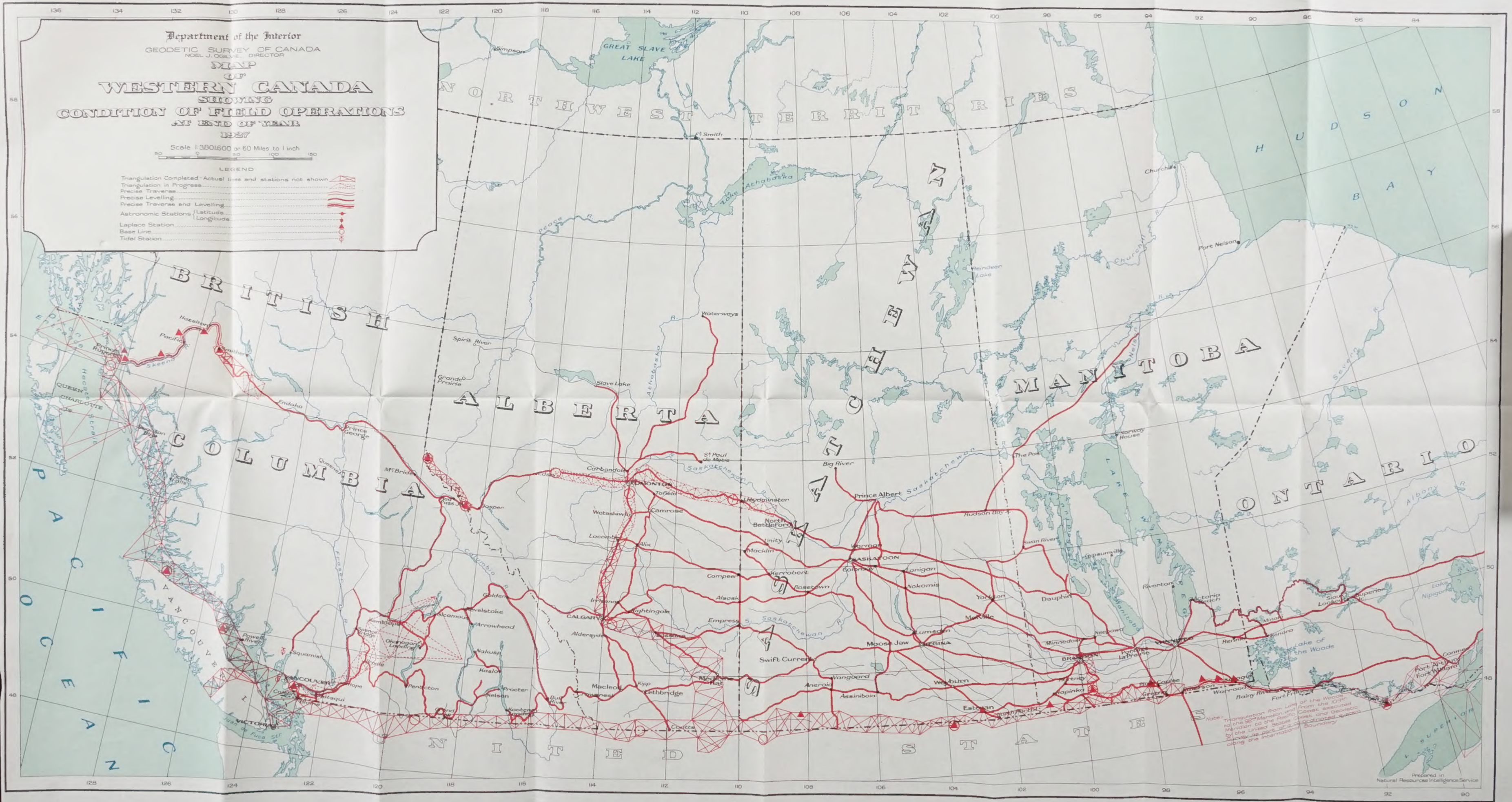


PHOTO-LITHOGRAPHED AT THE TOPOGRAPHICAL SURVEY OF CANADA, OTTAWA